A Field Oriented Natural Gas Hydrate Research Project for The Alaska North Slope – Resource Evaluation And Possible Testing

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Abstract

For years natural gas hydrates have portended potential multi-trillion cubic feet of primarily methane reserves both onshore and offshore. Recently, two major events have moved the hydrate curiosity to serious hydrate interest: (1) The perceived ensuing shortage of accessible cost effective energy for North America and other countries like Japan, and (2) The stimulus by the National Energy Technology Laboratory/US Department of Energy (NETL/DOE) hydrate program to fast forward hydrate technology.

Anadarko Petroleum Corp. along with Mauerer Technology and Noble Engineering are participating in the recent Alaska hydrate research program sponsored by NETL/DOE. This unique field oriented research project will apply known oil and gas technology with modification to recognize and access North Slope hydrate gas accumulations with a further plan to attempt long term well production testing of the wells that will be drilled during the project. The research program incorporated some of the unique approaches to the coring, core retrievable core assessment, well bore evaluation, including the various testing scenarios. On-site laboratory testing will be done when appropriated to understand the time function on some of the physical properties. Thermodynamics and kinetics data will be obtained from off-site measurements

Introduction

Gas hydrates occur naturally in permafrost and deep marine environments around the globe. It is estimated that methane in gas hydrates worldwide is more than 10^{13} tons of methane-carbon [1]. This quantity is equivalent to ~2.10^{16} cubic meters of methane gas, or about twice as much as all other fossil fuels, taken together. and about 370 times as much as all of the natural gas ever likely to be produced from conventional sources in North America [2]. Potentially, this resource could be the backbone for the world's energy sector during the 21st century.

Background

Several major factors have so far prevented the commercialization of gas hydrates to produce clean burning, environmentally friendly fuel. These factors are:

- Remoteness of the hydrate resources from major natural gas markets, except in several cases (offshore the East Coast of the United States, offshore Japan, offshore India, in the Black Sea, and offshore Australia);
- Insufficient knowledge about the in-situ properties of gas hydrates;
- Absence of economical and proven technology for the production of natural gas from gas hydrates;

Remoteness of the resource - no more. Even gas hydrates have been recovered in at least 90 locations in marine environments globally and in many cases in permafrost conditions onshore, these sites are often situated far from the major natural gas markets. For example, it would take a 5,000 km pipeline to bring gas from Alaska to the continental United States, and even if gas hydrates were to be successfully developed, the cost of transportation may be prohibitive. However, the situation changed when the N. America gas market get tight and several plans on gas pipeline from Alaska and Canada to the United States have been under intensive debate. The known gas resource on the North Slope, 35 trillion cubic feet (Tcf) are the energy equivalent to six billion barrels of oil, half the oil reserves in Prudhoe Bay. Up to 100 Tcf of gas could eventually be developed on the slope. This is not including the potential hydrate deposit under the permafrost and offshore Beaufort Sea. Due to its shallow depositional environment, hydrate can be a low cost energy source.

To evaluate the costs and benefits of bringing natural gas from gas hydrates to markets, the knowledge of the hydrate physical properties and the technologies for their production would first have to be developed and tested. Significant laboratory knowledge in gas hydrates is available, but the hands-on field experiences are few.

Insufficient knowledge – Improving. While it is easy to create gas hydrates in laboratory experiments, there are few hydrate samples (both in pressurized and non-pressurized containers) from natural deposits. In 1998, the completion of a 1150 meters hydrate test well Mallik 2L-38 in the MacKenzie Delta, NWT, Canada have made significant improvement in the knowledge base of naturally occurring hydrates [3]. The scientific project focused on geophysical measurements with limited hydrate coring. Approximately 37 meters of hydrate cores were recovered with very scarce publications on their test results. Such research requires the ability to recover, transport, prepare and analyze samples under controlled conditions identical to the ones in-situ. Currently there is no comprehensive program of this kind. The insufficient knowledge about gas hydrates properties in natural environments is a serious handicap for the development of technologies to produce methane from gas hydrates.

Absence of proven technologies – adopted and modified from existing industry. The Mallik well have employed several new and innovative coring designs and procedures with reasonable but limited success. There are several known technologies to extract natural gas from gas hydrates, mostly based on the use of techniques leading to the decomposition of the hydrates in-situ and the subsequent production of the gas by conventional or adapted gas wells. For example, gas hydrates decompose when the pressure and temperature are beyond certain limits, or when inhibitors are injected, and the gas is released and can be produced by wells.

There is one known case where natural gas has been commercially produced from gas hydrates for a sustained period of time. In permafrost onshore North Siberia in Russia, inhibitors were injected to cause the decomposition of the gas hydrates, and the released gas was produced at the Messoyakha gas field. Production was discontinued when it was judged uneconomic. In recent publications, the claim that the produced gas did actually originate from the gas hydrates, and not from free gas trapped under the gas hydrates in the Messoyakha field, has been disputed. It is inevitable that the hydrate production technology will be derived from the well-developed oil and gas practices. Under the contract terms with NETL/DOE, this research program will focus on the identification of the hydrate area, coring operation, test hydrate properties and monitor the wellbore. Production is only a secondary objective.

Site Selection and Permitting

Site selection is based on Anadarko proprietary seismic data and available public information from various well logs and temperature logs. The current selections of possible site are a balance between easy access to roads, potential hydrate thickness and safe operation conditions. Due to environmental concerns and regulatory stipulations in the Alaska Coastal and Foothill areas; the permitting processes are very lengthy. Other than the permitting requirements from the Federal and State agencies, local authorities, native and various citizen groups have to be informed of all drilling activities. The drilling season in the Arctic is only opened for the few months in winter. With all the logistic of mobilizing the equipment, the actual drilling window is very limited. Water and gravel usage to build ice road and site preparation is under rigorous control.

Drilling and Coring

Three straight holes will be drill and core from the permafrost through the hydrate zone. A small-footprint mining/coring rig will be used in the drilling and coring operation to minimize the environmental impacts in the tundra. Selection of coring equipment is underway with carefully planned operation procedures that meet all environmental and safety requirements. Fluid chilling will be used if the operational time frame will destabilize the hydrate core. Other than the thermodynamic properties, the kinetics reaction during coring of the hydrate is critical. The time-dependent hydrate freeze and thaw cycle in the presence of coring fluid may provide a self-preservation mechanism. Several drilling/coring fluids will be tested in the laboratory for its compatibility with the hydrate (laboratory simulated). The stringent requirement of the coring fluid will ensure and maximize core recovery. The data from laboratory measurement will feed into a computer wellbore simulator to ensure a safe operation. All equipment will be tested prior moving on location. Mud logging will be used to identify the hydrate stabilization zone. Gas and fluid compositions are good indicators.

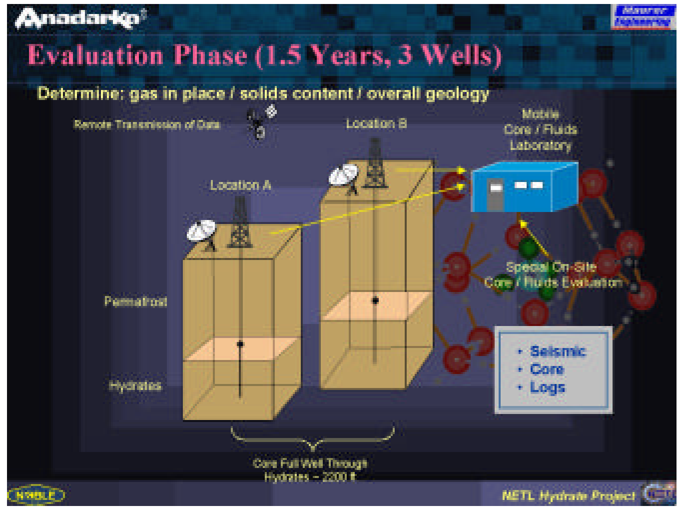

Fig. 1 Hydrate Evaluation Phase

Core Preservation and Laboratory Testing

The stability of gas hydrate is dependent on pressure, temperature and the solubility of gas as a function of pressure and temperature in the system. Understanding of the thermodynamic data of methane and other gas hydrates is very important from the view-point of preserving cores and exploiting natural gas production from hydrate wells. The hydrate handling experiences from various National Laboratories and the USGS indicated the stability of hydrate is more susceptible to changes in temperature than pressure during the time of coring and core preservation at the well site. During the coring operation, recovered cores will be kept at a specific (low) temperature to preserve its original properties by means of an insulated core holder. For longer term core storage, the hydrate cores will be kept in pressure core storage barrels and under proper temperature. Appropriate tests on-site and off-site using known laboratory techniques.

Geophysical and Petrophysical Properties. While the centerpiece of laboratory testing has been to understand the seismic response of hydrate and fluids and seismic relationships with petrophysical parameters, data can also be generated for reservoir quality evaluation, seismic characterization, petrophysical evaluation, and hydrate reservoir mechanical/chemical stability evaluation. The laboratory is highly automated with high sample throughput capability.

Thermal Properties. The basic properties important for understanding the thermal state of the hydrate reservoir are temperature, thermal conductivity and thermal diffusivity [4]. Time Temperature Transformation (TTT) profiles can be constructed from isothermal Differential Scanning Calorimetry (DSC) data. It will provide information about the complex nucleation and growth mechanism. This simple technique can be used to screen the efficiency of different chemical inhibitors. Results can provide heat flow Vs reference temperatures data with heats of fusion and crystallization resolving Ice and Hydrates distinctly

Table 1. Hydrate Core Characterization Measurements

Seismic	**Compression & Shear Velocities @various *P* & *T***
	Elastic Anisotropy
Petro -	**Porosity & Permeability @ various *P* &*T* (NMR)**
Physical	**Bulk and Grain Density**
	X-ray & FTIR Mineralogy
	Laser Particle Size Analysis
Engineering	**Compressive strength**
	Young's Modulus
Thermal	**Conductivity & Diffusivity**
	Heat of fusion
Chemical	**Carbon Isotope**
	Fluid & Gas Composition

Open Hole Logging and Completion

The basic sonic, SP and Gamma logs will be run after the cores are recovered. NMR is rather unique to apply in the investigation of hydrates. There are only two companies that can provide the NMR tool. Currently, only one will service the Alaska North Slope. The electronic logs will be analyzed in conjunction with the laboratory core testing results, the mud log data and seismic data. After the logs are done, these wells will be equipped with temperature strips and downhole pressure gauges for temperature and pressure profile monitoring. Various precautions will be observed to log the borehole temperature if fluids are accumulated inside the wellbore. Time will allow to let the wellbore to get in equilibrium with the surrounding formation. Simple techniques such as thermal stimulation will be applied to the wellbore to observe its respond.

Conclusions

The objective of this research project is to develop technologies that can be used for the continuation of a long-term product test at one or more hydrate sites in the arctic environment, and upon the confirmation of its viability, the immediate commercialization of the technology. The project is also expected to assess the natural gas reserves of gas hydrates resources in the arctic and the elaboration of recommendations to facilitate the commercialization of a vast, environmentally friendly source of fossil energy in Alaska and worldwide.

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